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Title of the Invention (280 characters max):

TNF-RELATED PROTEINS

60/119906

Enclosed application parts are:

☒ 34 pages of specification, 3 pages of claim(s), 1 pages of abstract, and ____ pages of sequence listing, totaling ____ pages

☒ 9 sheets of drawings

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TNF-RELATED PROTEINS

Field of the Invention

The present invention relates to proteins that are involved in inflammation and immunomodulation, particularly in B cell growth, survival, or activation. The invention further relates to proteins related to the tumor necrosis factor (TNF)/nerve growth factor (NGF) superfamily and related nucleic acids, expression vectors, host cells, and binding assays. The specification also describes compositions and methods for the treatment of immune-related and inflammatory, autoimmune and other immune-related diseases or disorders, such as rheumatoid arthritis (RA), Crohn's disease (CD), lupus, and graft versus host disease (GvHD).

The invention also relates to receptors for these TNF-related proteins and methods and compositions for the treatment of inflammatory and immune-related diseases and disorders using the receptors.

Background of the Invention

After years of study in necrosis of tumors, tumor necrosis factors (TNFs) α and β were finally cloned in 1984. The ensuing years witnessed the emergence of a superfamily of TNF cytokines, including fas ligand (FasL), CD27 ligand (CD27L), CD30 ligand (CD30L), CD40 ligand (CD40L), TNF-related apoptosis-inducing ligand (TRAIL, also designated AGP-1), osteoprotegerin binding protein (OPG-BP or OPG ligand), and 4-1BB ligand. This family is unified by its structure, particularly at the C-terminus. In addition, most members known to date are expressed in immune compartments, although some members are also expressed in other tissues or organs, as well. Smith et al. (1994), Cell 76: 959-62.

It is therefore an object of the invention to identify proteins and nucleic acids related to TNFs. Such proteins are believed to play a role in

inflammatory and immune processes, suggesting their usefulness in treating autoimmune and inflammatory disorders.

Summary of the Invention

In accordance with the present invention, a novel member of the tumor necrosis factor family is described. Unlike other members of this family, the receptor for this member is primarily expressed in B cells, and its expression correlates to increases in the number of B cells and immunoglobulins produced. The natural, preferred human ortholog is here called AGP-3 and contains 285 amino acids; the mouse ortholog, 309 amino acids. The protein is a type II transmembrane protein and has an amino terminal cytoplasmic domain, a transmembrane domain, and a carboxy terminal extracellular domain. TNF-related proteins of the invention may be membrane-associated or in soluble form, recombinantly produced or isolated after natural production.

The invention provides for nucleic acids encoding such TNF-related proteins, vectors and host cells expressing the polypeptides, and methods for producing recombinant proteins. Antibodies or fragments thereof that specifically bind proteins are also provided.

The subject proteins may be used in assays to identify cells and tissues that express AGP-3 or related proteins, and to identify new AGP-3-related proteins. Methods of identifying compounds that interact with AGP-3 protein are also provided. Such compounds include nucleic acids, peptides, proteins, carbohydrates, lipids or small molecular weight organic molecules and may act either as agonists or antagonists of AGP-3 protein activity.

AGP-3-related proteins are involved in B cell growth, survival, and activation, particularly in the lymph node, spleen, and Peyer's patches. AGP-3 agonists and antagonists thus modulate B cell response and may be used to treat diseases characterized by inflammatory processes or

deregulated immune response, such as RA, GvHD, CD, lupus, and the like. Pharmaceutical compositions comprising AGP-3 proteins and AGP-3 agonists and antagonists are also encompassed by the invention.

Description of the Figures

Figure 1 shows the sequence of human AGP-3. Nucleic acid and amino acid sequences of human AGP-3 are indicated (SEQ ID NOS: 1 and 2, respectively). The predicted transmembrane region is underlined. Potential N-linked glycosylation sites are shown in boldface.

Figure 2 shows the sequence of murine AGP-3. Nucleic acid and amino acid sequences of murine AGP-3 are indicated (SEQ ID NOS: 3 and 4, respectively). The predicted transmembrane region is underlined. Potential N-linked glycosylation sites are shown in boldface.

Figure 3 shows an alignment of human and murine AGP-3, along with a consensus sequence (SEQ ID NO: 5). The predicted human and murine AGP-3 protein sequences were aligned by Pileup with gap creation penalty (12) and gap extension penalty (4) (Wisconsin GCG Package, Version 8.1, Genetics Computer Group Inc., Madison, Wisconsin). The consensus sequence was determined by Lineup (Wisconsin GCG Package, Version 8.1). The transmembrane regions from amino acid 47 to 72 in human AGP3 and from amino acid 48 to 73 in murine AGP3 are underlined. The N-terminal intracellular domain resides from amino acid 1 to 46 in human AGP3 and from amino acid 1 to 47 in murine AGP3. The C-terminal extracellular domain is localized from amino acid 73 to 285 in human AGP3, and from amino acid 74 to 309. The human and murine AGP-3 share 68% amino acid identity overall. The C-terminus of AGP-3 is more conserved between human and mouse, with 87% identity over a 142-amino acid length. The putative conserved beta strands are indicated at the top, with the amino acids forming the putative strands underlined.

Figure 4 shows human and murine AGP-3 mRNA tissue distribution. Human tissue northern blots (A) and murine tissue northern blots (B) were probed with ^{32}P-labeled human AGP-3 probe (A) or murine AGP-3 probe. The probed blots were exposed to Kodak film for 18 hours (A) or seven days (B).

Figure 5 shows histology analysis of AGP-3 transgenic mouse spleen. The spleen sections from control mouse (A, C and E) and AGP-3 transgenic mouse (B, D, and F) were stained with hematoxylin and exosin (A and B), anti-mouse B220 (C and D) or anti-mouse CD3 (E and F). The spleen of the transgenic mouse was enlarged, mainly due to the increase of size and number of the follicles. The B cell staining areas in the spleen follicles in the transgenic mouse were enlarged. The T cell number was slightly diminished.

Figure 6 shows histology analysis of AGP-3 transgenic mouse lymph nodes. The lymph node sections from control mouse (A, C and E) and AGP-3 transgenic mouse (B, D, and F) were stained with hematoxylin and exosin (A and B), anti-mouse B220 (C and D) or anti-mouse CD3 (E and F). The lymph node size of the transgenic mouse was enlarged. The B cell number was greatly increased in the transgenic mouse. Instead of restricted to marginal zones of the follicles as in the control mouse, the B cells also filled out the follicular area in the lymph nodes of the transgenic mouse. The T cell number was decreased in the transgenic mouse as compared to the control.

Figure 7 shows histology analysis of AGP-3 transgenic mouse Peyer's patches. The Peyer's patches sections from control mouse (A, C and E) and AGP-3 transgenic mouse (B, D, and F) were stained with hematoxylin and exosin (A and B), anti-mouse B220 (C and D) or anti-mouse CD3 (E and F). The histologic and immunohistologic changes were similar to the changes in the lymph node of the transgenic mouse.

Figure 8 shows FACS analysis of thymocytes, splenocytes and lymph node cells from AGP-3 transgenic mouse. Single-cell suspensions were prepared from spleen, lymph nodes and thymus from 10 AGP-3 transgenic mice and 5 control littermates. Cells were stained with FITC or PE-conjugated monoclonal antibodies against Thy-1.2, B220, CD11b, Gr-1, CD4 or CD8. The B cell population increased by 100% in the transgenic mice as compared to the control mice. The T cell population decreased approximately 36%, with similar reductions in both CD4+ and CD8+ populations. Similar changes, though to a lesser degree, were observed in splenocytes. No differences in thymocyte staining were observed between the transgenic or control group.

Figure 9 shows a sequence comparison of the C-terminal region of members of the TNF ligand family determined via Pileup (Wisconsin GCG Package, Version 8.1). Amino acid numbers are indicated on the left side. The putative conserved beta strands and loops are indicated at the top. The predicted N-glycosylation sites are indicated with asterisks. The top line shows the consensus sequence (SEQ ID NO: 6). The remaining lines show the sequence for the C-terminal region of the mammalian TNF-related protein identified (SEQ ID NOS: 7 to 24).

Detailed Description of the Invention

The following definitions apply to the terms used throughout this specification, unless otherwise limited in specific instances.

The term "AGP-3 related protein" refers to natural and recombinant proteins comprising the following sequence:

QDCLQLIADSXTPTIXKGXYTFVPWLLSF

(SEQ ID NO: 25)

wherein "X" may be any naturally occurring amino acid residue. This sequence is a consensus of the B and B' β-sheets and B/B' loop of hAGP3 and mAGP3 (see Figure 3), which is believed to be the specific receptor

binding site. Preferred AGP-3 related proteins comprise both the B/B' consensus and the E/F consensus:

AMGHXIQRKKVHVFGDELSLVTLFR

(SEQ ID NO: 26)

The E/F region is also believed to be involved in receptor binding. More preferred proteins are those comprising the consensus of the B-I region:

QDCLQLIADS XTPTIXKGXY TFVPWLLSFK RGXALEEKEN KIXVXXTGYF FIYXQVLYTD XXXAMGHXIQ RKKVHVFGDE LSLVTLFRCI QNMFXTLPNN SCYSAGIAXL EEGDEXQLAI PRENAQISXX GDXTFFGALK LL

(SEQ ID NO: 27)

Most preferred proteins comprise the full C-terminal consensus sequence (SEQ ID NO: 5) or the B-I region of the human AGP-3 sequence (SEQ ID NO: 2). Such sequences can be included in naturally occurring proteins, truncated naturally occurring proteins, or recombinant and synthetic proteins. Recombinant and synthetic AGP-3 related proteins may be formed by fusion of the AGP-3 derived fragment with unrelated molecules or molecular domains (e.g., Fc regions), domain swapping with other TNF family members (e.g., substitution of SEQ. ID. NO: 6 or NOS: 6 and 7 in a sequence derived from a different TNF family member), antibody grafting (e.g., substituting SEQ. ID. NO. 6 for an antibody CDR), or other modifications. Such proteins are discussed further hereinbelow. The proteins may also be modified by linkage to a carbohydrate (e.g., dextran) or a water-soluble polymer (e.g., PEG). The proteins within this definition may also include substitution with amino acids serving as sites for attachment of non-protein groups (e.g., glycosylation sites). All such proteins are encompassed by the term "AGP-3 related protein."

"AGP-3 related activity" means that a natural or recombinant protein, analog, derivative or fragment is capable of modulating B cell growth, survival, or activation, particularly in MLN, spleen, and Peyer's patches. Such activity can be determined, for example, by such assays as

described in Example 5 hereinafter, which may be modified as needed by many methods known to persons having ordinary skill in the art.

An "analog" of an AGP-3 protein refers to a polypeptide within the definition of "AGP-3 related protein" that has a substitution or addition of one or more amino acids such that the resulting polypeptide has at least the property of eliciting B cell growth, survival, or activation. Such analogs will have substitutions or additions at any place along the polypeptide. Preferred analogs include those of soluble AGP-3 related proteins. Fragments or analogs may be naturally occurring, such as a polypeptide product of an allelic variant or a mRNA splice variant, or they may be constructed using techniques available to one skilled in the art for manipulating and synthesizing nucleic acids. The polypeptides may or may not have an amino terminal methionine residue.

A "derivative" of an AGP-3 protein is a polypeptide within the definition of "AGP-3 related protein" that has undergone post-translational modifications. Such modifications include, for example, addition of N-linked or O-linked carbohydrate chains, processing of N-terminal or C-terminal ends, attachment of chemical moieties to the amino acid backbone, chemical modifications of N-linked or O-linked carbohydrate chains, and addition of an N-terminal methionine residue due to prokaryotic host cell expression. In particular, chemically modified derivatives of AGP-3 related protein that provide additional advantages such as increased stability, longer circulating time, or decreased immunogenicity are contemplated. Of particular use is modification with water soluble polymers, such as polyethylene glycol and derivatives thereof (see for example U.S. Patent No. 4,179,337). The chemical moieties for derivitization may be selected from water soluble polymers such as polyethylene glycol, ethylene glycol/propylene glycol copolymers, carboxymethylcellulose, dextran, polyvinyl alcohol and the like. The

polypeptides may be modified at random positions within the molecule, or at predetermined positions within the molecule and may include one, two, three or more attached chemical moieties. Polypeptides may also be modified at pre-determined positions in the polypeptide, such as at the amino terminus, or at a selected lysine or arginine residue within the polypeptide. Other chemical modifications provided include a detectable label, such as an enzymatic, fluorescent, isotopic or affinity label to allow for detection and isolation of the protein.

The term "protein" refers to polypeptides regardless of length or origin, comprising molecules that are recombinantly produced or naturally occurring, full length or truncated, having a natural sequence or mutated sequence, with or without post-translational modification, whether produced in mammalian cells, bacterial cells, or any other expression system.

The invention provides for a protein referred to as an AGP-3 protein, which primarily acts on B cells. An EST bearing a portion of the AGP-3 sequence was obtained from a human fetal liver spleen cDNA library. A labeled cDNA fragment was used to probe a human spleen cDNA phage library (Example 1). The cDNA encoding a human AGP-3 was isolated from this phage library. The human protein is a type II transmembrane protein, having a short N-terminal intracellular region that differed from other members of the TNF ligand family and a long C-terminal extracellular region that comprises most of the conserved region of the TNF ligand family.

An EST encoding a murine ortholog was identified by BLAST search of Genebank using the human AGP-3 sequence. The corresponding cDNA clone was obtained from a mouse lymph node library and used to probe a mouse spleen cDNA phage library (Example 2). The cDNA encoding a murine AGP-3 ortholog was isolated from this phage library.

Northern blots were used to determine tissue distribution of transcription of AGP-3 (Example 3). In murine tissue, AGP-3 mRNA was detected mainly in spleen, lung, liver, and kidney. In human tissue, AGP-3 mRNA was detected predominantly in peripheral blood leukocytes, with weaker transcription in spleen, lung, and small intestine (see Figures 4A and 4B).

The murine ortholog of AGP-3 was overexpressed in transgenic mice (Example 4). In these transgenic mice, serum globulin and total protein levels increased greatly over control littermates while the albumin level remained the same (Example 5). The mice also exhibited increases in the size and number of follicles in the spleen, lymph nodes, and Peyer's patches (Figures 5, 6, and 7). In their MLN, the mice exhibited 100% increases in the number of cells expressing CD45 receptor with concomitant decreases in cells expressing CD90, CD4, and CD8. These results correspond to an increase in the B cell population and a decrease in the T cell population in the MLN (Figures 6 and 8). Similar results were obtained in the spleen, but to a lesser extent (Figures 5 and 8).

Nucleic Acids

The invention provides for isolated nucleic acids encoding AGP-3 related proteins. As used herein, the term nucleic acid comprises cDNA, genomic DNA, wholly or partially synthetic DNA, and RNA. These nucleic acids may be prepared or isolated as described in the working examples hereinafter or by nucleic acid hybridization thereof.

Nucleic acid hybridization typically involves a multi-step process. A first hybridization step forms nucleic acid duplexes from single strands. A second hybridization step under more stringent conditions selectively retains nucleic acid duplexes having the desired homology. The conditions of the first hybridization step are generally not crucial, provided they are not of higher stringency than the second hybridization step. Generally, the

second hybridization is carried out under conditions of high stringency, wherein "high stringency" conditions refers to conditions of temperature and salt that are about 12-20 °C below the melting temperature (T_m) of a perfect hybrid of part or all of the complementary strands corresponding to Figure 1 (SEQ ID NO: 1) and Figure 2 (SEQ ID NO: 3). In one embodiment, "high stringency" conditions refer to conditions of about 65 °C and not more than about 1 M Na^+. It is understood that salt concentration, temperature and/or length of incubation may be varied in either the first or second hybridization steps such that one obtains the hybridizing nucleic acid molecules according to the invention. Conditions for hybridization of nucleic acids and calculations of T_m for nucleic acid hybrids are described in Sambrook et al. (1989), Molecular Cloning: A Laboratory Manual Cold Spring Harbor Laboratory Press, New York.

The nucleic acids of the invention may hybridize to part or all of the polypeptide coding regions of AGP-3 related proteins (e.g., SEQ ID NOS: 2 and 4 as shown in Figures 1 and 2) and therefore may be truncations or extensions of the nucleic acid sequences shown therein. Truncated or extended nucleic acids are encompassed by the invention provided that the encoded proteins retain AGP-3 related activity. In one embodiment, the nucleic acid will encode a polypeptide of at least about 10 amino acids. In another embodiment, the nucleic acid will encode a polypeptide of at least about 20 amino acids. In yet another embodiment, the nucleic acid will encode a polypeptide of at least about 50 amino acids. The hybridizing nucleic acids may also include noncoding sequences located 5' and/or 3' to the coding regions for the AGP-3 related protein. Noncoding sequences include regulatory regions involved in expression of AGP-3 related protein, such as promoters, enhancer regions, translational initiation sites, transcription termination sites and the like.

In preferred embodiments, the nucleic acids of the invention encode mouse or human AGP-3 related protein. Most preferred are the nucleic acids encoding proteins of SEQ ID NOS: 2 and 4. Nucleic acids may encode a membrane-bound form of AGP-3 related protein or soluble forms that lack a functional transmembrane region. For human AGP-3 related protein, the predicted transmembrane region includes amino acid residues 47-72 inclusive as shown in Figure 1 (SEQ. ID. NO: 2); for murine AGP-3 related protein, residues 48-73 inclusive as shown in Figure 2 (SEQ ID NO: 4). Substitutions that replace hydrophobic amino acid residues in this region with neutral or hydrophilic amino acid residues would be expected to disrupt membrane association and result in soluble AGP-3 related protein. In addition, deletions of part or all the transmembrane region would also be expected to produce soluble forms of AGP-3 related protein. Nucleic acids encoding SEQ ID NO: 5 as shown in Figure 3 or fragments and analogs thereof, encompass soluble AGP-3 related proteins.

Nucleic acid sequences of the invention may also be used for the detection of sequences encoding AGP-3 related protein in biological samples. In particular, the sequences may be used to screen cDNA and genomic libraries for related AGP-3 related protein sequences, especially those from other species. The nucleic acids are also useful for modulating levels of AGP-3 related protein by anti-sense technology or in vivo gene expression. Development of transgenic animals expressing AGP-3 related protein is useful for production of the polypeptide and for the study of in vivo biological activity.

Vectors and Host Cells

The nucleic acids of the invention will be linked with DNA sequences so as to express biologically active AGP-3 related protein. Sequences required for expression are known to those skilled in the art and include promoters and enhancer sequences for initiation of RNA

synthesis, transcription termination sites, ribosome binding sites for the initiation of protein synthesis, and leader sequences for secretion. Sequences directing expression and secretion of AGP-3 related protein may be homologous, i.e., the sequences are identical or similar to those sequences in the genome involved in AGP-3 related protein expression and secretion, or they may be heterologous. A variety of plasmid vectors are available for expressing AGP-3 related protein in host cells (see, for example, Methods in Enzymology v. 185, Goeddel, D.V. ed., Academic Press (1990)). For expression in mammalian host cells, a preferred embodiment is plasmid pDSRα described in PCT Application No. 90/14363. For expression in bacterial host cells, preferred embodiments include plasmids harboring the lux promoter (see co-owned and co-pending U.S. Serial No. 08/577,778, filed December 22, 1995). In addition, vectors are available for the tissue-specific expression of AGP-3 related protein in transgenic animals. Gene transfer vectors derived from retrovirus (RV), adenovirus (AdV), and adeno-associated virus (AAV) may also be used for the expression of AGP-3 related protein in human cells for in vivo therapy (see PCT Application No. 86/00922).

Prokaryotic and eukaryotic host cells expressing AGP-3 related protein are also provided by the invention. Host cells include bacterial, yeast, plant, insect or mammalian cells. AGP-3 related protein may also be produced in transgenic animals, such as mice or goats. Plasmids and vectors containing the nucleic acids of the invention are introduced into appropriate host cells using transfection or transformation techniques known to one skilled in the art. Host cells may contain DNA sequences encoding AGP-3 related protein as shown in Figure 1, 2, or 3 or a portion thereof, such as the extracellular domain or the cytoplasmic domain. Nucleic acids encoding AGP-3 related proteins may be modified by substitution of codons that allow for optimal expression in a given host.

At least some of the codons may be so-called preference codons that do not alter the amino acid sequence and are frequently found in genes that are highly expressed. However, it is understood that codon alterations to optimize expression are not restricted to the introduction of preference codons. Examples of preferred mammalian host cells for AGP-3 related protein expression include, but are not limited to COS, CHOd-, 293 and 3T3 cells. A preferred bacterial host cell is Escherichia coli.

Polypeptides

The invention also provides AGP-3 related protein as the product of prokaryotic or eukaryotic expression of an exogenous DNA sequence. Exogenous DNA sequences include cDNA, genomic DNA and synthetic DNA sequences. AGP-3 related protein may be the product of bacterial, yeast, plant, insect or mammalian cells expression, or from cell-free translation systems. AGP-3 related protein produced in bacterial cells will have an N-terminal methionine residue. The invention also provides for a process of producing AGP-3 related protein comprising growing prokaryotic or eukaryotic host cells transformed or transfected with nucleic acids encoding AGP-3 related protein and isolating polypeptide expression products of the nucleic acids.

Polypeptides that are mammalian AGP-3 related proteins or are fragments, analogs or derivatives thereof are encompassed by the invention. In a preferred embodiment, the AGP-3 related protein is human AGP-3 related protein. A fragment of AGP-3 related protein refers to a polypeptide having a deletion of one or more amino acids such that the resulting polypeptide has at least the property of eliciting B cell growth, survival, or activation, especially in mesenteric lymph nodes. Said fragments will have deletions originating from the amino terminal end, the carboxy terminal end, and internal regions of the polypeptide. Fragments of AGP-3 related protein are at least about ten amino acids, at

least about 20 amino acids, or at least about 50 amino acids in length. In preferred embodiments, AGP-3 related protein will have a deletion of one or more amino acids from the transmembrane region (amino acid residues 48-73 as shown in Figure 1), or, alternatively, one or more amino acids from the amino-terminus up to and/or including the transmembrane region (amino acid residues 1-73 as shown in Figure 1).

The invention further comprises AGP-3 related protein chimeras. Such proteins comprise part or all of an AGP-3 related protein amino acid sequence fused to a heterologous amino acid sequence. The heterologous sequence may be any sequence that allows the resulting fusion protein to retain AGP-3 related activity. In preferred embodiments, a heterologous sequence is fused to a sequence comprising an AGP-3 related protein's B/B' region (SEQ ID NO: 25), the B/B' region and the E/F region (SEQ ID NO: 26) or the more complete B-J region (SEQ ID NO: 27). Such heterologous sequences include cytoplasmic domains that allow for alternative intracellular signaling events, sequences that promote oligomerization (e.g., the Fc region of IgG), enzyme sequences that provide a label for the polypeptide, and sequences that provide affinity probes (e.g., an antigen-antibody recognition site).

The polypeptides of the invention are isolated and purified from tissues and cell lines that express AGP-3 related protein, either extracted from lysates or from conditioned growth medium, and from transformed host cells expressing AGP-3 related protein. Human AGP-3 related protein, or nucleic acids encoding same, may be isolated from human lymph node or fetal liver tissue. Isolated AGP-3 related protein is free from association with human proteins and other cell constituents.

A method for purification of AGP-3 related protein from natural sources (e.g. tissues and cell lines that normally express an AGP-3 related protein) and from transfected host cells is also encompassed by the

invention. The purification process may employ one or more standard protein purification steps in an appropriate order to obtain purified protein. The chromatography steps can include ion exchange, gel filtration, hydrophobic interaction, reverse phase, chromatofocusing, affinity chromatography employing an anti-AGP-3 related protein antibody or biotin-streptavidin affinity complex and the like.

Antibodies

Antibodies specifically binding the polypeptides of the invention are also encompassed by the invention. The antibodies may be produced by immunization with full-length AGP-3 related protein, soluble forms of AGP-3 related protein, or a fragment thereof. The antibodies of the invention may be polyclonal or monoclonal, or may be recombinant antibodies, such as chimeric antibodies wherein the murine constant regions on light and heavy chains are replaced by human sequences, or CDR-grafted antibodies wherein only the complementarity determining regions are of murine origin. Antibodies of the invention may also be human antibodies prepared, for example, by immunization of transgenic animals capable of producing human antibodies (see, for example, PCT Application No. WO93/12227). The antibodies are useful for detecting AGP-3 related protein in biological samples, thereby allowing the identification of cells or tissues that produce the protein In addition, antibodies that bind to AGP-3 related protein and block interaction with other binding compounds may have therapeutic use in modulating B cell growth, activation, and/or proliferation.

Antibodies to AGP-3 related proteins may be useful in treatment of immune-related diseases or conditions. Such antibodies may bind to AGP-3, preventing AGP-3 binding to its receptors, and are thus competitive inhibitors (i.e., having AGP-3 antagonistic activity). Antibodies can be tested for binding to AGP-3 related protein and examined for their ability

to inhibit AGP-3-mediated B cell growth, survival, or activation associated with the disease or condition (see Example 5).

It is also anticipated that fragments, derivatives or analogs that lack AGP-3 agonistic activity will act as antagonists of the ligand:receptor interaction and inhibit ligand-mediated activity of the AGP-3 related protein. Such antagonists can be examined for their ability to inhibit AGP-3-mediated B cell growth, survival, or activation associated with the disease or condition (see Example 5).

Compositions

The invention also provides for pharmaceutical compositions comprising a therapeutically effective amount of the AGP-3 related protein of the invention together with a pharmaceutically acceptable diluent, carrier, solubilizer, emulsifier, preservative and/or adjuvant. The invention also provides for pharmaceutical compositions comprising a therapeutically effective amount of an AGP-3 related protein agonist or antagonist. The term "therapeutically effective amount" means an amount that provides a therapeutic effect for a specified condition and route of administration. The composition may be in a liquid or lyophilized form and comprises one or more of the following:

- a diluent (e.g., Tris, acetate or phosphate buffers) having various pH values and ionic strengths;
- a solubilizer (e.g., Tween or Polysorbate);
- carriers (e.g., human serum albumin or gelatin);
- preservatives (e.g., thimerosal or benzyl alcohol); and
- antioxidants (e.g., ascorbic acid or sodium metabisulfite).

Selection of a particular composition will depend upon a number of factors, including the condition being treated, the route of administration and the pharmacokinetic parameters desired. A more extensive survey of component suitable for pharmaceutical compositions is found in

activity associated with AGP-3 related protein, such as ability to elicit B cell growth, survival, or activation in MLN, spleen, and Peyer's patches. Typically, an agonist or antagonist may be a co-factor, such as a protein, peptide, carbohydrate, lipid or small molecular weight molecule, that interacts with AGP-3 related protein to regulate its activity. Potential polypeptide antagonists include antibodies that react with either soluble or membrane-associated forms of AGP-3 related protein, and soluble forms of AGP-3 related protein that comprise part or all of the extracellular domain of AGP-3 related protein. Molecules that regulate AGP-3 related protein expression typically include nucleic acids that are complementary to nucleic acids encoding AGP-3 related protein and that act as anti-sense regulators of expression.

AGP-3 and agonists thereof may be particularly useful in treatment of inflammatory conditions of the joints. Inflammatory conditions of a joint are chronic joint diseases that afflict and disable, to varying degrees, millions of people worldwide. Rheumatoid arthritis is a disease of articular joints in which the cartilage and bone are slowly eroded away by a proliferative, invasive connective tissue called pannus, which is derived from the synovial membrane. The disease may involve peri-articular structures such as bursae, tendon sheaths and tendons as well as extra-articular tissues such as the subcutis, cardiovascular system, lungs, spleen, lymph nodes, skeletal muscles, nervous system (central and peripheral) and eyes (Silberberg (1985), Anderson's Pathology, Kissane (ed.), II:1828). Osteoarthritis is a common joint disease characterized by degenerative changes in articular cartilage and reactive proliferation of bone and cartilage around the joint. Osteoarthritis is a cell-mediated active process that may result from the inappropriate response of chondrocytes to catabolic and anabolic stimuli. Changes in some matrix molecules of articular cartilage reportedly occur in early osteoarthritis (Thonar et al.

(1993), Rheumatic disease clinics of North America, Moskowitz (ed.), 19:635-657 and Shinmei et al. (1992), Arthritis Rheum., 35:1304-1308). AGP-3 and agonists thereof are believed to be useful in the treatment of these and related conditions.

AGP-3 related protein and agonists or antagonists thereof may also be useful in treatment of a number of additional diseases and disorders, including acute pancreatitis; ALS; Alzheimer's disease; cachexia/anorexia; asthma; atherosclerosis; chronic fatigue syndrome, fever; diabetes (e.g., insulin diabetes); glomerulonephritis; graft versus host rejection; hemohorragic shock; hyperalgesia, inflammatory bowel disease; inflammatory conditions of a joint, including osteoarthritis, psoriatic arthritis and rheumatoid arthritis; ischemic injury, including cerebral ischemia (e.g., brain injury as a result of trauma, epilepsy, hemorrhage or stroke, each of which may lead to neurodegeneration); lung diseases (e.g., ARDS); multiple myeloma; multiple sclerosis; myelogenous (e.g., AML and CML) and other leukemias; myopathies (e.g., muscle protein metabolism, esp. in sepsis); osteoporosis; Parkinson's disease; pain; sleep disturbance; neurotoxicity (e.g., as induced by HIV); learning impairment; pre-term labor; psoriasis; reperfusion injury; septic shock; side effects from radiation therapy, temporal mandibular joint disease, tumor metastasis; or an inflammatory condition resulting from strain, sprain, cartilage damage, trauma, orthopedic surgery, infection or other disease processes.

Agonists and antagonists of AGP-3 related protein may be administered alone or in combination with a therapeutically effective amount of other drugs, including analgesic agents, disease-modifying anti-rheumatic drugs (DMARDs), non-steroidal anti-inflammatory drugs (NSAIDs), and any immune and/or inflammatory modulators. Thus, agonists and antagonists of AGP-3 related protein may be administered with:

- Modulators of other members of the TNF/TNF receptor family, including TNF antagonists, such as Enbrel™, sTNF-R1, and Avakine™.
- Nerve growth factor (NGF) modulators.
- IL-1 inhibitors, such as IL-1ra, IL-1 antibodies, solubilized IL-1 receptor, and the like.
- IL-6 inhibitors (e.g., antibodies to IL-6).
- IL-8 inhibitors (e.g., antibodies to IL-8).
- IL-18 inhibitors (e.g., IL-18 binding protein or IL-18 antibodies).
- Interleukin-1 converting enzyme (ICE) modulators.
- Transforming growth factor-β (TGF-β), TGF-β family members, and TGF-β modulators.
- Fibroblast growth factors FGF-1 to FGF-10, and FGF modulators.
- Osteoprotegerin (OPG) and OPG analogues.
- PAF antagonists.
- Keratinocyte growth factor (KGF), KGF-related molecules, and KGF modulators.
- COX-2 inhibitors, such as Celebrex™ and Vioxx™.
- Prostaglandin analogs (e.g., E series prostaglandins).
- Matrix metalloproteinase (MMP) modulators.
- Nitric oxide synthase (NOS) modulators, including modulators of inducible NOS.
- Modulators of glucocorticoid receptor.
- Modulators of glutamate receptor.
- Modulators of lipopolysaccharide (LPS) levels.
- Anti-cancer agents, including inhibitors of oncogenes (e.g., fos, jun) and interferons.

- Noradrenaline and modulators and mimetics thereof.

Assay Methods of Use

AGP-3 related proteins may be used in a variety of assays for detecting AGP-3 receptors, agonists, antagonists and characterizing interactions with AGP-3 related proteins. In general, the assay comprises incubating AGP-3 related protein under conditions that permit measurement of AGP-3 related activity as defined above. Qualitative or quantitative assays may be developed. Assays may also be used to identify new AGP-3 agonists or antagonists and AGP-3 related protein family members.

Binding of natural or synthesized receptor, agonist, or antagonist to AGP-3 related protein may be carried out in several formats, including cell-based binding assays, membrane binding assays, solution-phase assays and immunoassays. In general, trace levels of a labeled binding molecule are incubated with AGP-3 related protein samples for a specified period of time followed by measurement of bound molecule by filtration, electrochemiluminescent (ECL, ORIGEN system by IGEN), cell-based or immunoassays. Homogeneous assay technologies for radioactivity (SPA; Amersham) and time-resolved fluoresence (HTRF, Packard) can also be implemented. Binding is detected by labeling a binding molecule (e.g., an anti-AGP-3 antibody) with radioactive isotopes (125I, 35S, 3H), fluorescent dyes (fluorescein), lanthanide (Eu3+) chelates or cryptates, orbipyridyl-ruthenium (Ru^{2+}) complexes. It is understood that the choice of a labeled probe will depend upon the detection system used. Alternatively, a binding molecule may be modified with an unlabeled epitope tag (e.g., biotin, peptides, His_6, myc) and bound to proteins such as streptavidin, anti-peptide or anti-protein antibodies that have a detectable label as described above.

Binding molecules in such assays may be nucleic acids, proteins, peptides, carbohydrates, lipids or small molecular weight organic compounds. The binding molecule may be substantially purified or present in a crude mixture. The binding molecules may be further characterized by their ability to increase or decrease AGP-3 related protein activity in order to determine whether they act as an agonist or an antagonist.

In an alternative method, AGP-3 related protein may be assayed directly using polyclonal or monoclonal antibodies to AGP-3 related proteins in an immunoassay. Additional forms of AGP-3 related proteins containing epitope tags as described above may be used in solution and immunoassays.

AGP-3 related proteins are also useful for identification of intracellular proteins that interact with the cytoplasmic domain by a yeast two-hybrid screening process. As an example, hybrid constructs comprising DNA encoding the N-terminal 50 amino acids of an AGP-3 related protein fused to a yeast GAL4-DNA binding domain may be used as a two-hybrid bait plasmid. Positive clones emerging from the screening may be characterized further to identify interacting proteins. This information may help elucidate an intracellular signaling mechanism associated with AGP-3 related protein and provide intracellular targets for new drugs that modulate inflammatory and immune-related diseases and conditions.

A variety of assays may be used to measure the interaction of AGP-3 related protein and agonists, antagonists, or other ligands in vitro using purified proteins. These assays may be used to screen compounds for their ability to increase or decrease the rate or extent of binding to AGP-3 related protein. In one type of assay, AGP-3 related protein can be immobilized by attachment to the bottom of the wells of a microtiter plate.

A radiolabeled binding molecule and a test molecule can then be added either one at a time (in either order) or simultaneously to the wells. After incubation, the wells can be washed and counted using a scintillation counter for radioactivity to determine the extent of binding to AGP-3 related protein. Typically, molecules will be tested over a range of concentrations, and a series of control wells lacking one or more elements of the test assays can be used for accuracy in evaluation of the results. An alternative to this method involves reversing the "positions" of the proteins; i.e., immobilizing a binding molecule to the microtiter plate wells, incubating with the test compound and radiolabeled AGP-3 related protein, and determining the extent of binding. See, for example, chapter 18 of Current Protocols in Molecular Biology (1995) (Ausubel et al., eds.), John Wiley & Sons, New York, NY.

As an alternative to radiolabeling, AGP-3 related protein or a binding molecule may be conjugated to biotin and the presence of biotinylated protein can then be detected using streptavidin linked to an enzyme, such as horseradish peroxidase (HRP) or alkaline phosphatase (AP), that can be detected colorimetrically, or by fluorescent tagging of streptavidin. An antibody directed to AGP-3 related protein or a binding molecule that is conjugated to biotin may also be used and can be detected after incubation with enzyme-linked streptavidin linked to AP or HRP.

AGP-3 related protein or a binding molecule may also be immobilized by attachment to agarose beads, acrylic beads or other types of such inert substrates. The substrate-protein complex can be placed in a solution containing the complementary protein and the test compound; after incubation, the beads can be precipitated by centrifugation, and the amount of binding between AGP-3 related protein and a binding molecule can be assessed using the methods described above. Alternatively, the substrate-protein complex can be immobilized in a column and the test

molecule and complementary molecule passed over the column. Formation of a complex between AGP-3 related protein and the binding molecule can then be assessed using any of the techniques set forth above (i.e., radiolabeling, antibody binding, and the like).

Another useful in vitro assay is a surface plasmon resonance detector system, such as the Biacore assay system (Pharmacia, Piscataway, NJ). The Biacore system may be carried out using the manufacturer's protocol. This assay essentially involves covalent binding of either AGP-3 related protein or a binding molecule to a dextran-coated sensor chip that is located in a detector. The test compound and the other complementary protein can then be injected into the chamber containing the sensor chip either simultaneously or sequentially and the amount of complementary protein that binds can be assessed based on the change in molecular mass that is physically associated with the dextran-coated side of the of the sensor chip; the change in molecular mass can be measured by the detector system.

In vitro assays such as those described above may be used advantageously to screen rapidly large numbers of compounds for effects on complex formation with AGP-3 related protein. The assays may be automated to screen compounds generated in phage display, synthetic peptide and chemical synthesis libraries.

Compounds that increase or decrease complex formation of AGP-3 related protein and AGP-3 binding molecules may also be screened in cell culture using cells and cell lines bearing such ligands. Cells and cell lines may be obtained from any mammal, but preferably will be from human or other primate, canine, or rodent sources. Such cells may be enriched from other cell types by affinity chromatography using publicly available procedures. Attachment of AGP-3 related protein to such cells is evaluated in the presence or absence of test compounds and the extent of binding

may be determined by, for example, flow cytometry using a biotinylated antibody to AGP-3 related protein. Cell culture assays may be used advantageously to further evaluate compounds that score positive in protein binding assays described above.

The following examples are offered to more fully illustrate the invention, but are not construed as limiting the scope thereof.

EXAMPLE 1

Cloning of Human AGP-3

A TNF family profile search of the Genbank dbEST data base was performed. Smith et al.(1994), Cell, 76: 959-62; Luethy et al.(1994), Protein Science, 3: 139-46. One human EST sequence (GenBank accession number T87299) was identified as a possible new member of the TNF ligand. The EST was obtained from human fetal liver spleen cDNA library (The WashU-Merck EST Project). The cDNA clone (115371 3') corresponding to the EST sequence was obtained from Genome Systems, Inc. (St. Louis, MO). The cDNA fragment was released from the pT7T3D vector with EcoRI and NotI digestion. The fragment was approximately 0.7 kb in length and was used for the subsequent full-length cloning.

The ^{32}P-dCTP-labeled T87299 cDNA fragment was used as a probe to screen a human spleen cDNA phage library (Stratagene, La Jolla, CA). Recombinant phages were plated onto E. coli strain XL1-blue at approximately 5 x 10^4 transformants per 150 mm LB plate. Nitrocellulose filters were lifted from these plates in duplicates. Filters were prehybridized in 5x SSC, 50% deionized formamide, 5x Denhardt's solution, 0.5% SDS, and 100 µg/ml denatured salmon sperm DNA for 2 hours at 42 °C. The filters were then hybridized in the same solution with the addition of 5 ng/ml of labeled probe at 42°C overnight. The filters were first washed in 2x SSC and 0.1% SDS for 10 minutes at RT twice, and

then washed in 0.1x SSC and 0.1% SDS at 65 °C for 30 minutes twice. The filters were then exposed to autoradiography with intensifying screens at -80 °C overnight. Positive hybridizing plaques were determined by aligning the duplicate filters, and then picked up for subsequent secondary or tertiary screening till single isolated positive plaque was obtained. From total of one million recombinant phage clones, 8 positive plaques were obtained.

The pBluescript phagemid was excised from phage using the ExAssist™/SOLR™ System according to the manufacturer's description (Stratagene, La Jolla, CA). The excised phagemids were plated onto freshly grown SOLR cells on LB/ampicillin plates and incubated overnight. Single bacteria colony was amplified in LB media containing 100 µg/ml ampicillin. The plasmid DNA was prepared and both strands of cDNA insert were sequenced.

The human AGP-3 cDNA (clone 13-2) is 1.1 kb in length. It encodes a LORF of 285 amino acids. FASTA search of the SwissProt database with the predicted AGP-3 protein sequence indicated that it is mostly related to human TNFα with 25% identity in C-terminal 116 amino acid overlap. Like other TNF ligand family members, human AGP-3 protein is a type II transmembrane protein, containing a short N-terminal intracellular domain (amino acids 1-46), a hydrophobic transmembrane region (amino acids 47-68) following by a long C-terminal extracellular domain (amino acid 69-285). The C-terminal extracellular domain of AGP-3 contained most of the conserved region of the TNF ligand family. Smith et al.(1994), Cell, 76: 959-62.

EXAMPLE 2

Cloning of Murine AGP-3

An EST sequence (Genebank accession number AA254047) encoding a potential murine AGP-3 ortholog was identified by BLAST

search of Genebank dbEST database with human AGP-3 sequence. The corresponding cDNA clone (722549 5') from mouse lymph node library was obtained from Genome Systems, Inc. (St. Louis, MO). The clone contained a 0.9 kb cDNA insert which could be released by EcoRI and NotI digestion. The 0.9 kb cDNA fragment encodes an open reading frame of 96 amino acids which shares 87% identity with the corresponding C-terminal human AGP-3 polypeptide sequence. A 0.41 kb EcoRI-XmnI fragment, which contained 290 bp coding region and 120 bp 3' non-coding region, was used as probe to screening a mouse spleen cDNA phage library (Stratagene, La Jolla, CA) for full length murine AGP-3 cDNA as described above. From one million recombinant phage clones, 6 positive plaques were obtained. The phagemid was excised from phage as described above. The plasmid DNA was prepared and both strands of cDNA insert were sequenced. The murine AGP-3 cDNA (clone S6) encodes a polypeptide of 309 amino acids. Like its human ortholog, murine AGP-3 is also a type II transmembrane region, containing a short N-terminal intracellular domain (amino acid 1-46), a hydrophobic transmembrane region (amino acid 47-68) following by a long C-terminal extracellular domain (amino acid 69-285). The human and murine AGP-3 share 68% amino acid sequence identity overall. However, the C-terminal 142 amino acid sequences share 87% identity between the two species. Preceding the highly conserved C-terminus region, there is an insertion of 30 extra amino acids in the murine AGP-3. Four out of 7 positive phage plaques were independent clones, yet they all shared the same coding sequences.

EXAMPLE 3

Expression of human and murine AGP-3 mRNA

Multiple human or murine tissue northern blots (Clontech, Palo Alto, CA) were probed with ^{32}P-dCTP labeled human AGP-3 0.7kb EcoRI-

NotI fragment or murine AGP-3 0.41kb EcoRI-XmnI fragment, respectively. The Northern blots were prehybridized in 5x SSC, 50% deionized formamide, 5xDenhardt's solution, 0.5% SDS, and 100 µg/ml denatured salmon sperm DNA for 2 hours at 42 °C. The blots were then hybridized in the same solution with the addition of 5ng/ml of labeled probe at 42°C overnight. The filters were first washed in 2x SSC and 0.1% SDS for 10 minutes at RT twice, and then washed in 0.1x SSC and 0.1% SDS at 65 °C for 30 minutes twice. The blots were then exposed to autoradiography. The human tissue northern blot analysis with human AGP-3 probe under stringent conditions revealed predominant AGP-3 transcripts with a related molecular mass of 2.4kb in peripheral blood leukocytes (Figure 4A). Weaker expression was also detected in human spleen, lung and small intestine (Figure 4A). Among murine tissues analyzed, murine AGP-3 mRNA, with a relative molecular mass of 2kb, was mainly detected in spleen, lung, liver and kidney (Figure 4B).

EXAMPLE 4

Overexpression of murine AGP-3 in transgenic mice

Murine AGP-3 cDNA clone S6 in pBluescript SK(-) in pBluescript was used as template to PCR the entire coding region. T3 primer

5' AAT TAA CCC TCA CTA AAG GG 3"

SEQ ID NO: 28

was used as 5' PCR primer. The 3' end PCR primer, which contained a XhoI site, was

5' TCT CCC TCG AGA TCA CGC ACT CCA GCA AGT GAG 3'

SEQ ID NO: 29

PCR reactions were carried in a volume of 50 µl with 1 unit of vent DNA polymerase (New England Biolabs) in 20 mM Tris-HCl pH 8.8, 10 mM $(NH_4)_2SO_4$, 0.1% Triton-X100, 10 µM of each dNTP, 1 µM of each primer and 10 ng of murine AGP-3 cDNA template. Reactions were performed in

94 °C for 45 s, 55 °C for 55 S, and 72 °C for 2 minutes, for a total of 35 cycles. The PCR fragment created a XhoI site at 3' end after the AGP-3 coding region. The 1 kb PCR fragment was purified by electrophoresis, and digested with XbaI (present in the pBluescript MCS, 80 bp upstream of AGP-3 starting Methione) and XhoI restriction enzymes. The XbaI-XhoI PCR fragment was cloned into expression vector under the control of the human β-actin promoter. Graham et al.(1997), Nature Genetics 17: 272-4; Ray et al.(1991), Genes Dev. 5: 2265-73. The PCR fragment was sequenced to ensure no mutation. The murine AGP-3 expression plasmid was purified through two rounds of CsCl density gradient centrifugation. The purified plasmid was digested with ClaI, and a 6 kb fragment containing murine AGP-3 transgene was purified by gel electrophoresis. The purified fragment was resuspended in 5 mM Tris, pH 7.4, 0.2 mM EDTA at 2 µg/ml concentration. Single-cell embryos from BDF1 x BDF1-bred mice were injected as described (WO97 /23614). Embryos were cultured overnight in a CO_2 incubator and 15-20 2-cell embryos were transferred to the oviducts of pseudopregnant CD1 female mice.

Following term pregnancy, 62 offspring were obtained from implantation of microinjected embryos. The offspring were screened by PCR amplification of the integrated transgene in genomic DNA samples. Ear pieces were digested in 20 µl ear buffer (20mM Tris, pH8.0, 10mM EDTA, 0.5% SDS, 500 µg/ml proteinase K) at 55°C overnight. The sample was diluted with 200 µl of TE, and 2µl of the ear sample was used for the PCR reaction. The 5' PCR primer

5' AAC AGG CTA TTT CTT CAT CTA CAG 3'

SEQ ID NO: 30

resided in the murine AGP-3 coding region. The 3' PCR primer

5' CTC ATC AAT GTA TCT TAT CAT GTC T 3'

SEQ ID NO: 31

resided in the vector 3' to the murine AGP-3 transgene. The PCR reactions were carried in a volume of 50 µl with 0.5 unit of Taq DNA polymerase (Boehringer Mannheim, Indianapolis, IN) in 10 mM Tris-HCl pH 8.3, 50 mM KCl, 2.5 mM $MgCl_2$, 10 µM of each dNTP, 1 µM of each primer and 2 µl of ear sample. The mixtures were first heated at 94 °C for 2 min, and the PCR reactions were performed in 94 °C for 30 s, 55 °C for 30 s, and 72 °C for
45 s, for a total of 35 cycles. Of the 62 offspring, 10 were identified as PCR positive transgenic founders.

At 8 weeks of age, all ten transgenic founders (animal 3, 6, 9, 10, 13, 38, 40, 58, 59, and 62) and five controls (animal 7, 8, 11, 12 and 14) were sacrificed for necropsy and pathological analysis. Portions of spleen were removed, and total cellular RNA was isolated from the spleens of all the transgenic founders and negative controls using the Total RNA Extraction Kit (Qiagen Inc., Chartsworth, CA). The expression of the transgene was determined by RT-PCR. The cDNA was synthesized using the SuperScript™ Preamplification System according to the manufacturer's instructions (Gibco BRL, Gaithersburg, MD). The primer

5' CTC ATC AAT GTA TCT TAT CAT GTC T 3'

SEQ ID NO: 32

which was located in the expression vector sequence 3' to the AGP-3 transgene, was used to prime cDNA synthesis from the transgene transcripts. Ten µg total spleen RNA from transgenic founders and controls were incubated with 1 µM of primer at 70°C for 10 min, and placed on ice. The reaction was then supplemented with 10 mM Tris-HCl pH 8.3, 50 mM KCL, 2.5 mM $MgCl_2$, 10 µM of each dNTP, 0.1 mM DTT and 200 U SuperScript II RT. After incubation at 42 °C for 50 min, the reaction was stopped by heating at 72 °C for 15 min. Total RNA were digested by addition of 2 U RNase H and incubation at 37 °C for 20 min.

Subsequent PCR reactions were carried out by using murine AGP-3 specific primers. The 5' PCR primer was

5' AGC CGC GGC CAC AGG AAC AG 3'

SEQ ID NO: 33

The 3' PCR primer was

5' TGG ATG ACA TGA CCC ATA G 3'

SEQ ID NO: 34

The PCR reaction was performed in a volume of 50 µl with 0.5 unit Tag DNA polymerase in 10 mM Tris-HCl pH 8.3, 50mM KCL, 2.5mM $MgCl_2$, 10 µM of each dNTP, 1 µM of each primer and 1 µl of cDNA product. The reaction was performed at 94 °C for 30 s, 55°C for 30 S, and 72 °C for 1 min, for a total of 35 cycles. The PCR product was analyzed by electrophoresis. Transgene expression was detected in the spleen of all ten AGP-3 transgenic mice founders.

EXAMPLE 5

Biological activity of AGP-3

Prior to euthanasia, all animals were weighed, anesthetized by isofluorane and blood was drawn by cardiac puncture. The samples were subjected to hematology and serum chemistry analysis. The serum globulin level in all the AGP-3 transgenic mice (animal 3, 6, 9, 10, 13, 38, 40, 58, 59 and 62) increased more than 100% as compared to the control littermates (animal 7, 8, 11, 12 and 14, Table 1). Total protein level also increased correspondingly in the transgenic group, while albumin level remained the same. No significant differences in other serum chemistry or hematology parameters were observed at this age.

Radiography was performed after terminal exsanguination. There was no difference in the radiodensity or radiologic morphology of the skeleton. Upon gross dissection, major visceral organs were subject to weight analysis. The spleen weight relative to the body weight increased

by approximately 45% in the AGP-3 transgenic group as compared to the control mice. The sizes of lymph nodes and Peyer's patches were also increased substantially in all the AGP-3 transgenic mice.

Following gross dissection, tissues were removed and fixed in 10% buffered Zn-Formalin for histological examination. The tissues collected were liver, spleen, pancreas, stomach, the entire gastrointestinal tract, kidney, reproductive organs, skin and mammary glands, bone, brain, heart, lung, thymus, trachea, esophagus, thyroid, adrenals, urinary bladder, lymph nodes and skeletal muscle. After fixation, the tissues were processed into paraffin blocks, and 3 µm sections were obtained. All sections were stained with hematoxylin and exosin, and subject to histologic analysis. The size and the number of the follicles in the spleen, lymph nodes and Peyer's patches were increased significantly in the AGP-3 transgenic mice (Figure 5, 6 and 7). The spleen, lymph node and Peyer's patches of both the transgenic and the control mice were subject to immunohistology analysis with B cell and T cell specific antibodies. The formalin fixed paraffin embedded sections were deparaffinized and hydrated to deionized water. The sections were quenched with 3% hydrogen peroxide, blocked with Protein Block (Lipshaw, Pittsburgh, PA), and incubated in rat monoclonal anti-mouse B220 and CD3 (Harlan, Indianapolis, IN), respectively. The binding was detected by biotinylated rabbit anti-rat immunoglobulins and peroxidase conjugated streptavidin (BioGenex, San Ramon, CA) with DAB as chromagen (BioTek, Santa Barbara, CA). Sections were counterstained with hematoxylin. The B cell numbers, as indicated by positive B220 staining, increased significantly in the spleen, lymph nodes and Peyer's batches (Figure 5, 6, and 7). The T cell numbers, as indicated by the anti-CD3 staining, were slightly decreased. There were no differences in the morphology of the thymus between the transgenic and the control group. By immunohistology, the T cell

population was similar in numbers. At 8 weeks of age, there are no distinctive morphologic changes in the liver, kidneys, or urinary, central nervous, hematopoietic, skeletal, respiratory, gastrointestinal, endocrine, or reproductive systems.

After necropsy, MLN and sections of spleen and thymus from 10 AGP-3 transgenic mice (animals 3, 6, 9, 10, 13, 38, 40, 58, 59 and 62) and 5 control littermates (animals 7, 8, 11, 12, and 14) were removed. Single cell suspensions were prepared by gently grinding the tissues with the flat end of a syringe against the bottom of a 100 µm nylon cell strainer (Becton Dickinson, Franklin Lakes, NJ). Cells were washed twice in a 15 ml volume then counted. Approximately 1 million cells from each tissue was stained with 0.5 µg antibody in a 100 µl volume of PBS (without Calcium and Magnesium) + 0.1% Bovine Albumin + 0.01% Sodium Azide. All spleen and MLN samples were incubated with 0.5 µg CD16/32(FcγIII/II) Fc block in a 20 µl volume for 10 minutes prior to the addition of FITC or PE-conjugated monoclonal antibodies against CD90.2 (Thy-1.2), CD45R (B220), CD11b(Mac-1), Gr-1, CD4, or CD8 (PharMingen, San Diego, CA) at 2-8 °C for 30 min. The cells were washed then analyzed by flow cytometry using a FACScan (Becton Dickinson, San José, CA). Thymus samples were stained with FITC conjugated anti-Thy-1.2, FITC conjugated anti-CD4, and PE conjugated anti-CD8 (PharMingen, San Diego, CA).

In the MLN of the AGP-3 transgenic mice, the percentage of B220 positive B cells increased by 100% (Figure 6). The percentage of the Thy-1.2 positive T cells decreased approximately 36%, with similar reductions in both CD4(+) and CD8(+) populations. The helper CD4(+) / suppressor CD8(+) ratio remained unchanged. Similar increases in B cell and reductions in T cell populations were also observed in the spleens of the AGP-3 transgenic mice (Figure 8), though to a lesser extent. No obvious changes in staining with anti-CD11b or anti-Gr-1 antibodies were

observed in the lymph node and spleen between the transgenic and the control group. In the thymus, there were no differences in the percentages of Thy-1.2(+), CD4(+), CD8(+) or CD4(+)CD8(+) populations between the AGP-3 transgenic and the control mice.

Abbreviations

Abbreviations as used throughout this specification are defined as follows, unless otherwise defined in specific instances.

CDR	complementarity determining region
EST	expressed sequence tag
ORF	open reading frame
SDS	sodium dodecyl sulfate
TNF	tumor necrosis factor

* * *

While the present invention has been described in terms of the preferred embodiments, it is understood that variations and modifications will occur to those skilled in the art. Therefore, it is intended that the appended claims cover all such equivalent variations that come within the scope of the invention as claimed.

What is claimed is:

1. An isolated or recombinant polypeptide having a sequence comprising SEQ ID NO: 25.
2. The polypeptide of Claim 1, further comprising SEQ ID NO: 26.
3. The polypeptide of Claim 1 having a sequence comprising SEQ ID NO: 27.
4. The polypeptide of Claim 1 having a sequence comprising SEQ ID NO: 5.
5. A polypeptide of Claim 1 capable of eliciting B cell growth, survival, or activation in mesenteric lymph nodes.
6. The polypeptide of Claim 5, wherein the sequence comprises SEQ ID NO: 2.
7. The polypeptide of Claim 5, wherein the sequence comprises SEQ ID NO: 4.
8. The polypeptide of Claim 5, wherein the sequence further comprises the C' through I region of SEQ ID NO: 6.
9. An isolated nucleic acid encoding a protein of any of Claims 1 to 8.
10. The nucleic acid of Claim 9 including one or more codons preferred for Escherichia coli expression.
11. The nucleic acid of Claim 9 having a detectable label attached thereto.
12. An expression vector comprising the nucleic acid of Claim 9.
13. An expression vector comprising the nucleic acid of Claim 10.
14. A host cell transformed or transfected with the expression vector of Claim 12.
15. A host cell transformed or transfected with the expression vector of Claim 13.
16. The host cell of Claim 14, wherein the cell is a prokaryotic cell.
17. The host cell of Claim 15 wherein the cell is a prokaryotic cell.
18. The host cell of Claim 16, wherein the cell is Escherichia coli.

19. The host cell of Claim 17, wherein the cell is Escherichia coli.

20. A process for producing an AGP-3 protein comprising:

(a) growing under suitable nutrient conditions host cells transformed or transfected with the nucleic acid of Claim 9; and

(b) isolating the polypeptide product of the expression of the nucleic acid.

21. A polypeptide produced by the process of Claim 20.

22. The protein of any of Claims 1 to 8, wherein the protein has been covalently modified with a water-soluble polymer.

23. The protein of Claim 22 wherein the polymer is polyethylene glycol.

24. An antibody or fragment thereof which specifically binds the polypeptide of Claim 1.

25. The antibody of Claim 24 which is a monoclonal antibody.

26. A method for detecting the presence of an AGP-3 related protein in a biological sample comprising:

(a) incubating the sample with the antibody of Claim 24 under conditions that allow binding of the antibody to the AGP-3 related protein; and

(b) detecting the bound antibody.

27. A method to assess the ability of a candidate compound to bind to an AGP-3 related protein comprising:

(a) incubating the AGP-3 related protein with the candidate compound under conditions that allow binding; and

(b) measuring the bound compound.

28. The method of Claim 27 wherein the compound is an agonist or an antagonist of an AGP-3 related protein.

29. A method of regulating expression of an AGP-3 related protein in an animal comprising administering to the animal a nucleic acid complementary to the nucleic acid of Claim 9.

30. A pharmaceutical composition comprising a therapeutically effective amount of a protein of Claim 1 in a pharmaceutically acceptable carrier, adjuvant, solubilizer, stabilizer and/or anti-oxidant.

31. A method of modulating B cell growth, survival, or activation in a mammal comprising administering a therapeutically effective amount of a modulator of the protein of Claim 1.

32. The method of Claim 31 wherein the modulator is an antibody, or fragment thereof, which specifically binds an AGP-3 related protein.

A-570-P

TNF-RELATED PROTEINS

Abstract

A novel member of the tumor necrosis factor family is described. This member is primarily expressed in B cells and its expression correlates to increases in the number of B cells and immunoglobulins produced. The natural, preferred human ortholog is here called AGP-3 and contains 285 amino acids, the mouse 309 amino acids. The protein is a type II transmembrane protein and has an amino terminal cytoplasmic domain, a transmembrane domain, and a carboxy terminal extracellular domain. TNF-related proteins of the invention may be membrane-associated or in soluble form, recombinantly produced or isolated after natural production. The invention provides for nucleic acids encoding such TNF-related proteins, vectors and host cells expressing the polypeptides, and methods for producing recombinant proteins. Antibodies or fragments thereof that specifically bind the proteins are also provided.

FIGURE 1

Human AGP3

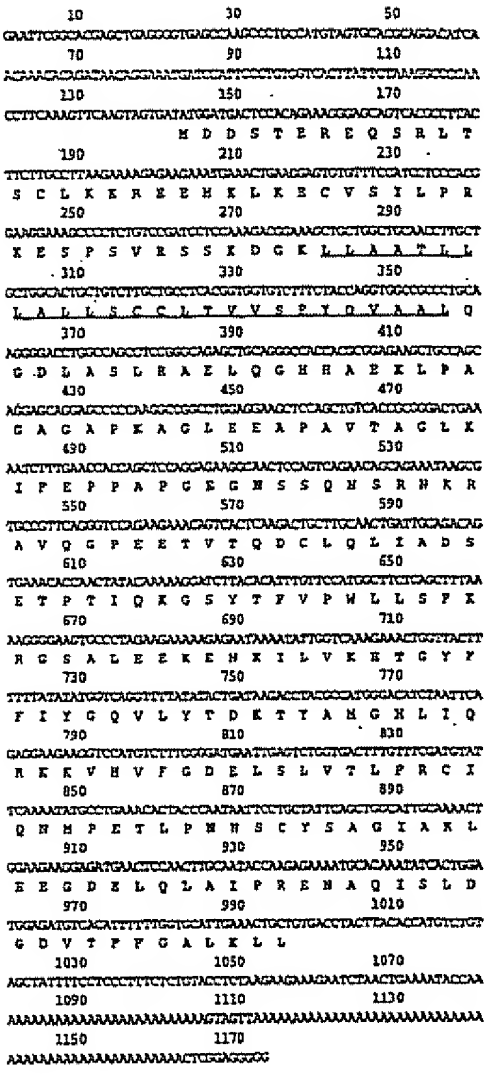

FIGURE 2

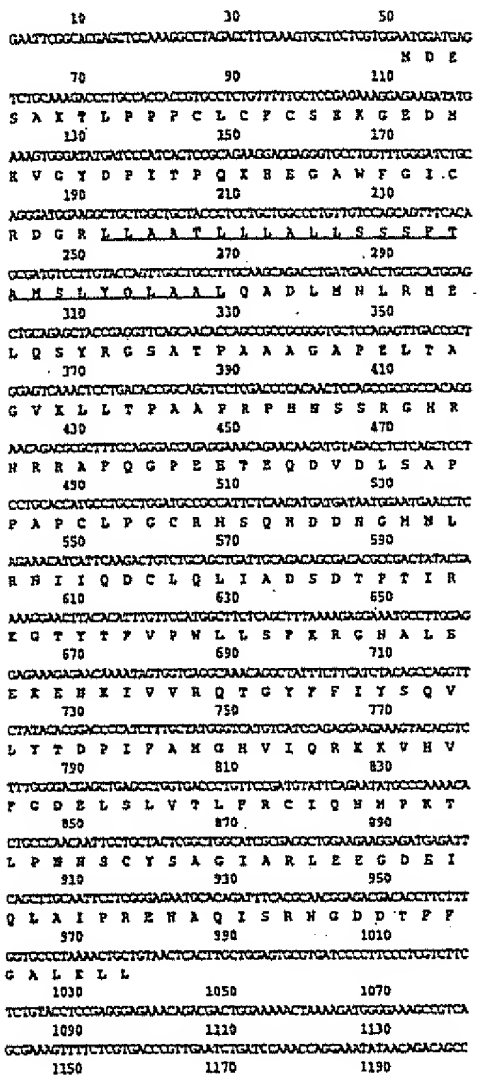

FIGURE 3

Alignment of human and murine AGP3 protein sequences

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Hagp3  MDDSTER.EQ SRLTSCLKKR EEMKLKECVS ILPRKESPSV RSSKDGKLLA
Magp3  MDESAKTLPP PCLCFCSEKG EDMKVGYDPI TPQKEEGANF GICRDGRLLA
cons   MD.S..... ..L..C..K. E.MK..... .....E.... ....DG.LLA

Hagp3  ATLLLALLSC CLTVVSFYQV AALQGDLASL RAELQGHHAE KLPAGAGAPK
Magp3  ATLLLALLSS SFTAMSLYQL AALQADLMNL RMELQSYRGS ATPAAAGAPE
cons   ATLLLALLS. ..T..S.YQ. AALQ.DL..L R.ELQ..... ..PA.AGAP.

Hagp3  AGLEEAPAVT AGLKIFEPPA PGEGNSSQNS RNKRAVQGPE ET........
Magp3  .........LT AGVKLLTPAA PRPHNSSRGH RNRRAFQGPE ETEQDVDLSA
cons   .........T AG.K...P.A P...NSS... RN.RA.QGPE ET........

                                                  B
Hagp3  .......... .......... ...VTQDCLQ LIADSETPTI QKGSYTFVPW
Magp3  PPAPCLPGCR HSQHDDNGMN LRNIIQDCLQ LIADSDTPTI RKGTYTFVPW
cons   .......... .......... .....QDCLQ LIADS.TPTI .KG.YTFVPW

       B'      C'      C          D              E
Hagp3  LLSEKRGSAL EEKENKILVK GTGYFFIYGQ VLYTDKTYAM GHLIQRKKVH
Magp3  LLSEKRGNAL EEKENKIVVR QTGYFFIYSQ VLYTDPIFAM GHVIQRKKVH
cons   LLSFKRG.AL EEKENKI.V. .TGYFFIY.Q VLYTD...AM GH.IQRKKVH

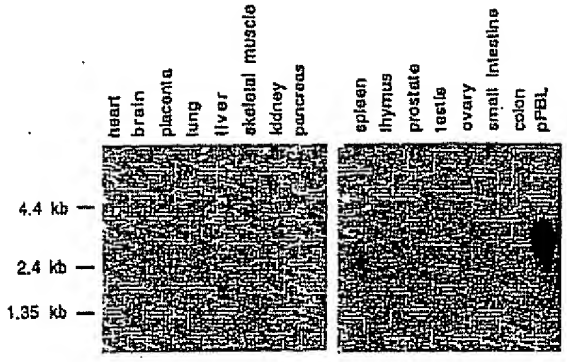
          F                          G              H
Hagp3  VFGDELSLVT LFRCIQNMPE TLPNNSCYSA GIAKLEEGDE LQLAIPRENA
Magp3  VFGDELSLVT LFRCIQNMPK TLPNNSCYSA GIARLEEGDE IQLAIPRENA
cons   VFGDELSLVT LFRCIQNMP. TLPNNSCYSA GIA.LEEGDE .QLAIPRENA

          I
Hagp3  QISLDGDVTP FGALKLL
Magp3  QISRNGDDTP FGALKLL
cons   QIS..GD.TP FGALKLL
```

FIGURE 4

A

Tissue Distribution of Human AGP3



B

Tissue Distribution of Murine AGP3

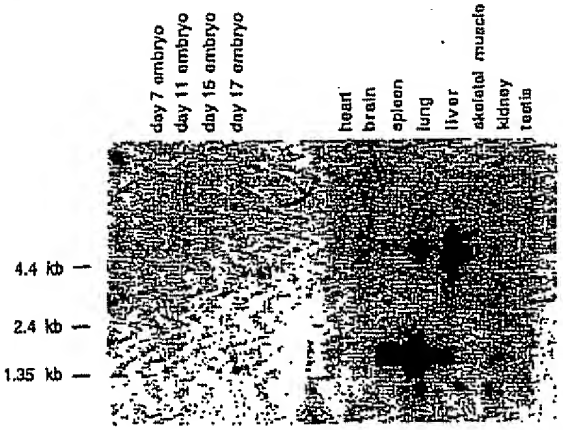
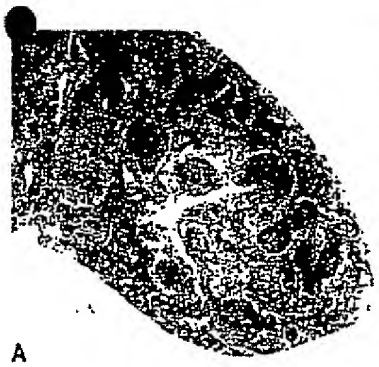


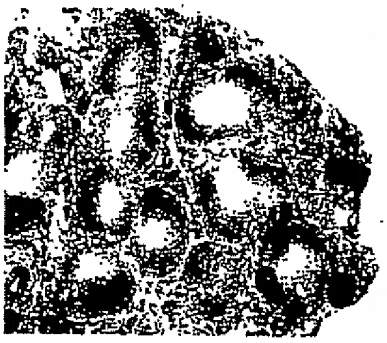
FIGURE 5



A

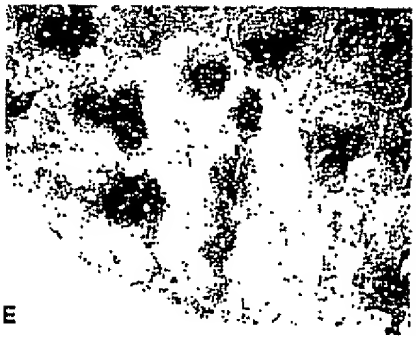
98M297 HH5 - control spleen, H&E, 2x

98M297 HH5 - expressor spleen, H&E, 2x



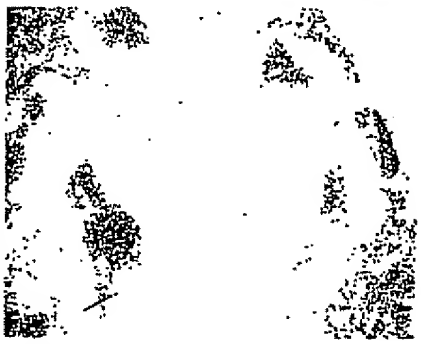
98M297 HH5 - control spleen, B220, 2x

98M297 HH5 - expressor spleen, B220, 2x



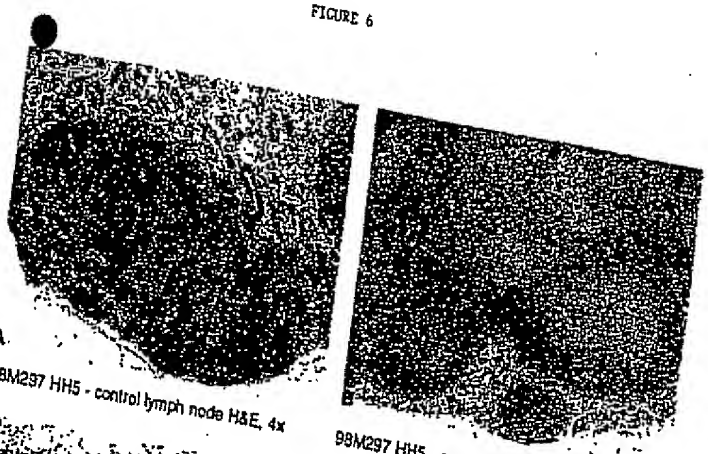
E

98M297 HH5 - control spleen, CD3, 2x



98M297 HH5 - expressor spleen, CD3, 2x

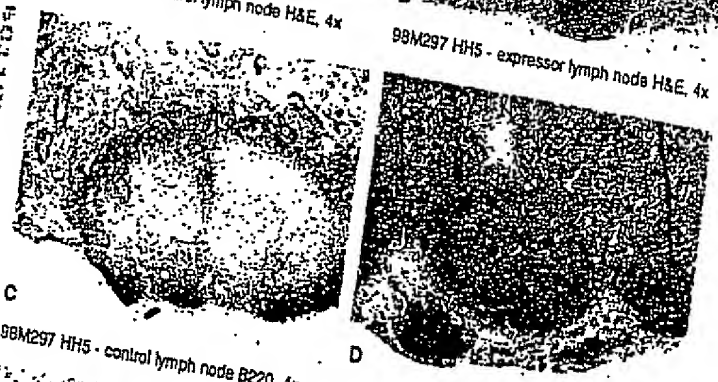
FIGURE 6



A.

98M297 HH5 - control lymph node H&E, 4x

98M297 HH5 - expressor lymph node H&E, 4x

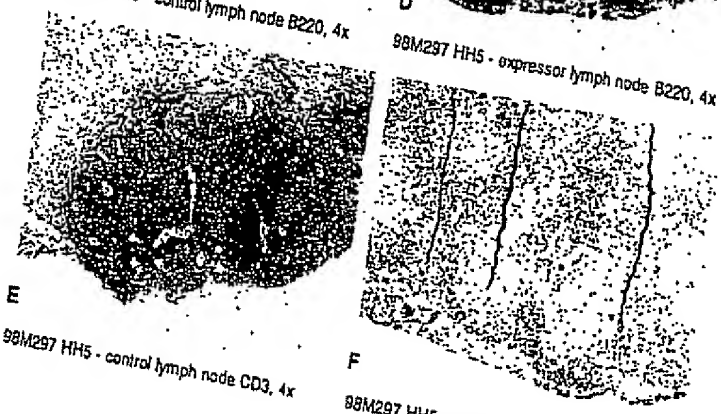


C

98M297 HH5 - control lymph node B220, 4x

D

98M297 HH5 - expressor lymph node B220, 4x



E

98M297 HH5 - control lymph node CD3, 4x

F

98M297 HH5 - expressor lymph node CD3, 4x

FIGURE 7

A

98M297 HH5 - control Payer's patch H&E, 4x

B

98M297 HH5 - expressor Payer's patch H&E, 4x

C

98M297 HH5 - control Payer's patch B220, 4x

D

98M297 HH5 - expressor Payer's patch B220, 4x

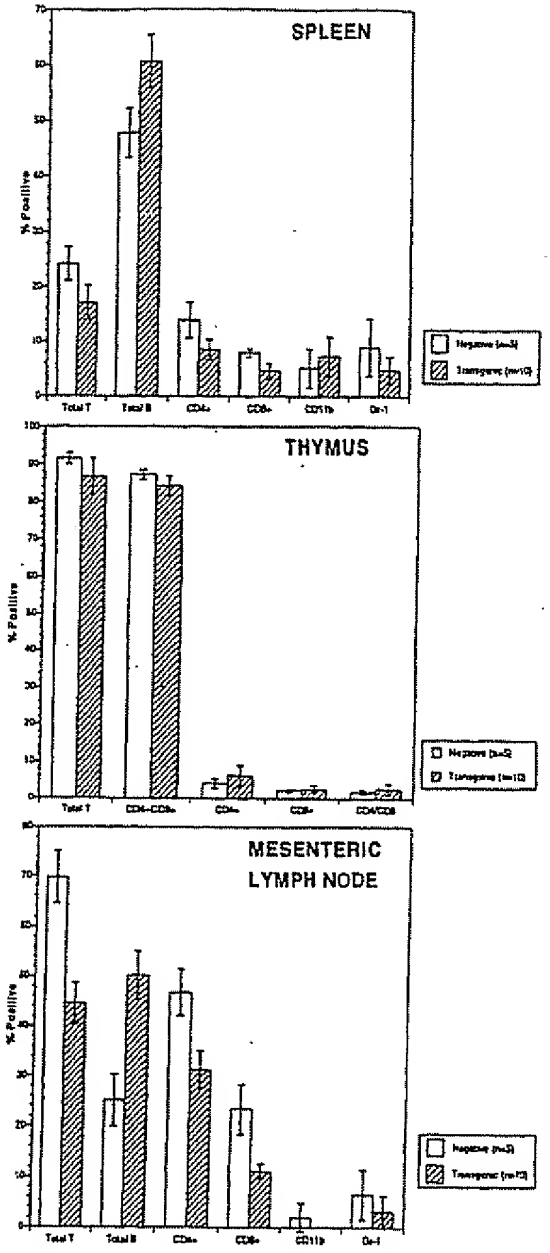
E

98M297 HH5 - control Payer's patch CD3, 4x

F

98M297 HH5 - expressor Payer's patch CD3, 4x

FIGURE 8


SPLEEN
% Positive
THYMUS
% Positive
MESENTERIC
LYMPH NODE
% Positive

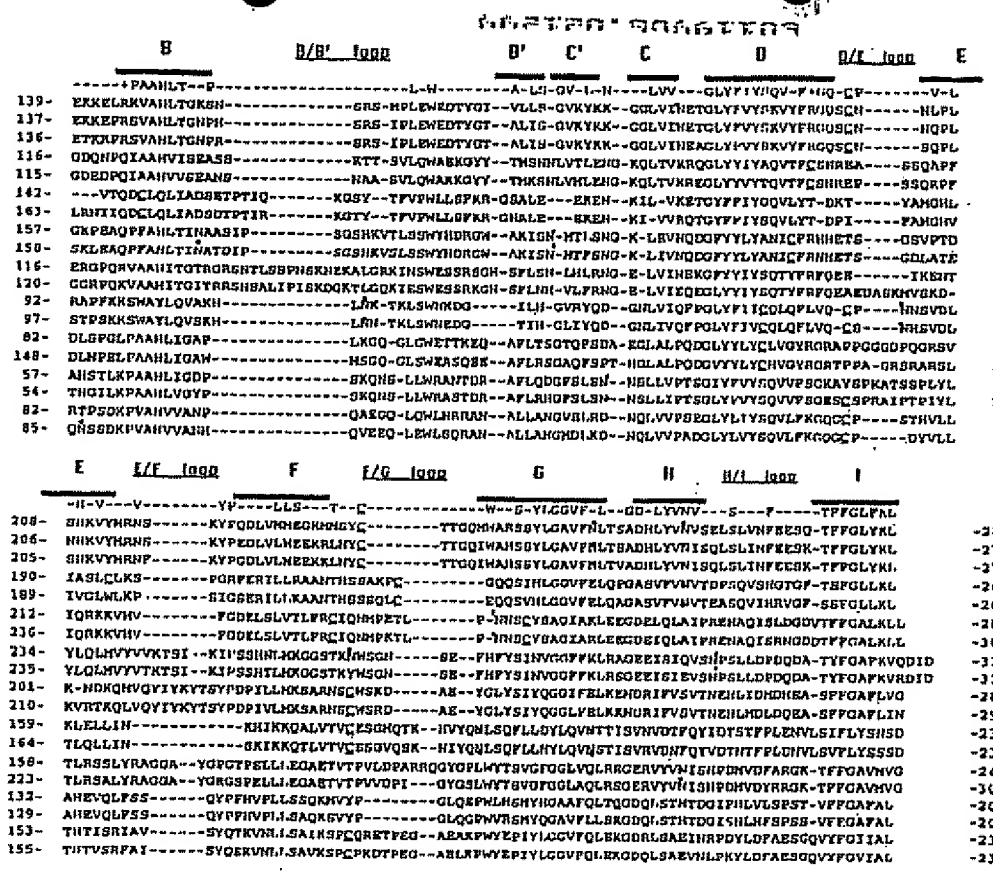

B
B/B' loop
B'
C'
C
D
D/E loop
E
E
E/F loop
F
F/G loop
G
H
H/I loop
I
Consensus
Human FasL
Mouse FasL
Rat FasL
Human CD40L
Mouse CD40L
Human AGP3
Mouse AGP3
Mouse OPGL
Human OPGL
Human TRAIL
Mouse TRAIL
Human CD30L
Mouse CD30L
Human LyTβ
Mouse LyTβ
Human TNFβ
Mouse TNFβ
Human TNFα
Mouse TNFα

FIGURE 6